Microwave Mega-Node

Issue A

KAY ELECTRIC CO.

KAY ELECTRIC COMPANY

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Microwave Mega-Node

INSTRUCTION MANUAL

ISSUE A

KAY ELECTRIC CO. • PINE BROOK, N. J.

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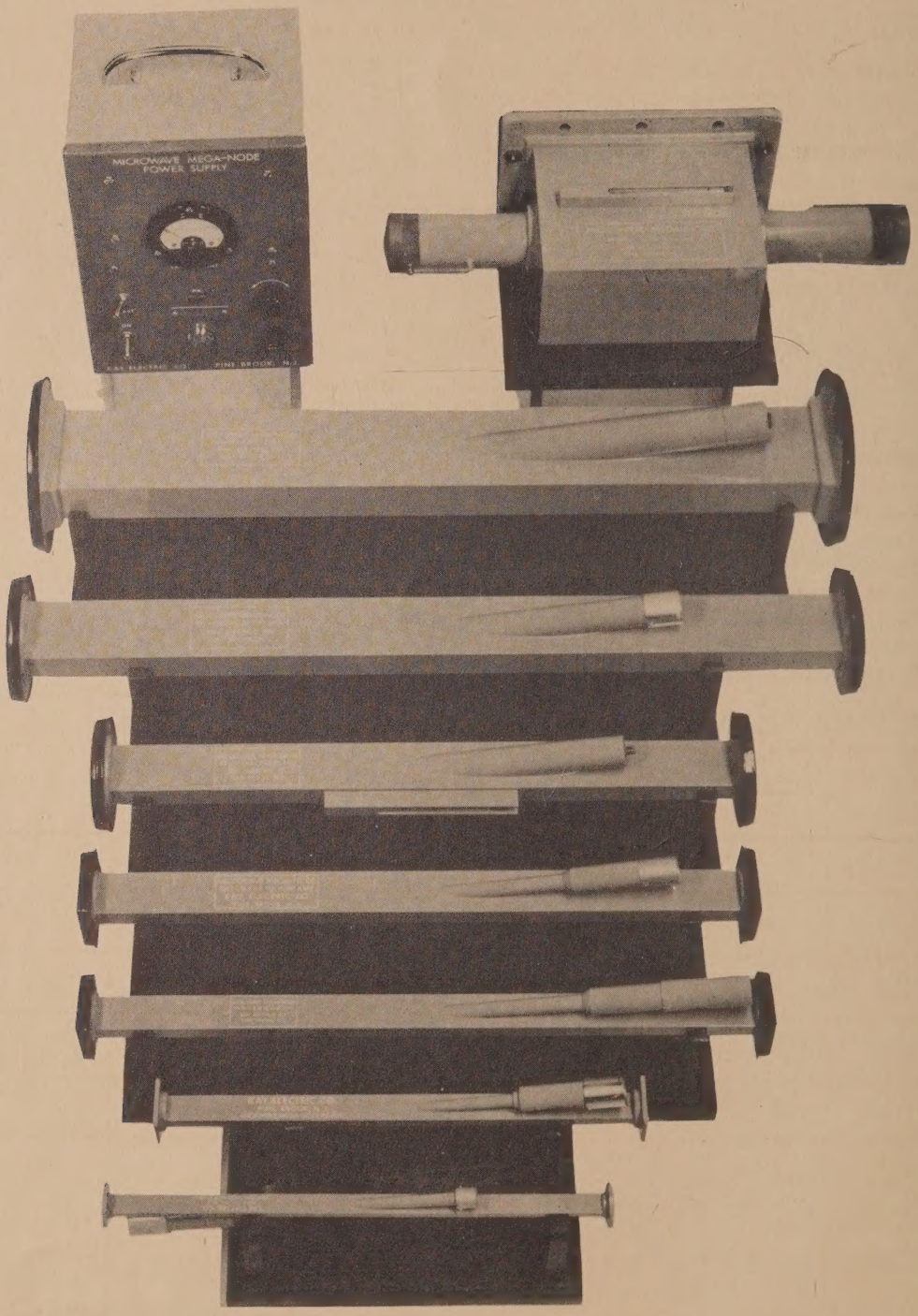


Fig. 1 **MICROWAVE MEGA-NODES**

SECTION I
GENERAL DESCRIPTION

A. PURPOSE.

THE **MICROWAVE MEGA-NODES** CONSTITUTE A SERIES OF EIGHT, RANDOM-NOISE GENERATORS, COVERING THE FREQUENCY RANGES 1200 TO 1400 MC AND 2600 TO 26,500 MC. THEY ARE DESIGNED TO BE USED IN NOISE FIGURE CALCULATIONS, SIGNAL CALIBRATION MEASUREMENTS, RECEIVER GAIN TESTS, AND/OR OVERALL PERFORMANCE CHECKS. ANY OF THE ABOVE INFORMATION MAY BE OBTAINED BY COMPARING THE NOISE OUTPUT OF THE SYSTEM UNDER TEST WITH THE KNOWN NOISE LEVEL INTRODUCED BY THE **MICROWAVE MEGA-NODE.**

B. DESCRIPTION.

EACH OF THE **MICROWAVE MEGA-NODES** INCLUDES A POWER SUPPLY UNIT AND A SEPARATE WAVEGUIDE ASSEMBLY. THE WAVEGUIDE ASSEMBLY CONSISTS OF A STANDARD JAN WAVEGUIDE, EACH END TERMINATED IN A JAN FLANGE. THE NOISE SOURCE CONSISTS OF EITHER A CONVENTIONAL FLUORESCENT TUBE OR AN ARGON GAS TUBE. IN EACH OF THE **MICROWAVE MEGA-NODES** EXCEPT THE **RG-69/U,** THE NOISE TUBE IS MOUNTED AT AN ACUTE ANGLE THROUGH THE MIDDLE OF THE WAVEGUIDE, TO MINIMIZE THE POSSIBILITY OF IMPEDANCE VARIATION WITH THE CURRENT. ON ALL MODELS UTILIZING THE FLUORESCENT NOISE SOURCE, A CENTIGRADE THERMOMETER IS BUILT INTO THE WAVEGUIDE ASSEMBLY TO FACILITATE THE ACCURATE DETERMINATION OF THE TEMPERATURE CORRECTION FACTOR. IN EQUIPMENT USING THE ARGON TUBES, THE OUTPUT IS SUBSTANTIALLY INDEPENDENT OF TEMPERATURE.

THE POWER SUPPLY IS COMPLETELY ENCLOSED IN A SMALL METAL CABINET ON WHICH ALL CONTROLS AND INDICATORS ARE MOUNTED. THE REAR OF THE POWER SUPPLY CABINET IS USED AS A STORAGE SPACE FOR THE INTERCONNECTING CABLES. THE POWER SUPPLY FOR WAVEGUIDES USING THE ARGON TUBE DIFFERS FROM THE FLUORESCENT TUBE POWER SUPPLY BOTH IN INPUT REQUIREMENTS AND FRONT-PANEL CONTROLS. IN ADDITION TO THE STANDARD FLUORESCENT AND ARGON POWER SUPPLIES, A SPECIAL POWER SUPPLY IS REQUIRED FOR THE **RG-69/U** AND THE **RG-48/U.** IN LATER MODELS, A SINGLE UNIVERSAL POWER SUPPLY IS USED FOR ALL ARGON AND FLUORESCENT NOISE SOURCES.

C. SPECIFICATIONS.

1. OPERATING RANGE AND IMPEDANCES.

JAN WAVEGUIDE NUMBER	LAMP SIZE		RECOMMENDED RANGE, $TE_{0,2}$ MODE	VSWR
	FLUORESCENT	ARGON		
RG-69/U †	GE-F14T12W, 14 WATT	RXB-103167	1.2-1.4 KMC	1.07:1 MAX.
RG-48/U †	T-8, 15 WATT	TD-12	2.6-3.95 KMC	F > 2.79, 1.1:1; 1.2:1 MAX.
RG-49/U †	T-5, 8 WATT	TD-10	3.95-5.85 KMC	< 1.1:1
RG-50/U †	T-5, 8 WATT	TD-10	5.85-8.2 KMC	F < 7.5, 1.1:1; 1.2:1 MAX.
RG-51/U †	T-5, 8 WATT	TD-11	7.05-10.0 KMC	< 1.1:1
RG-52/U †	T-5, 8 WATT	TD-11	8.2-12.4 KMC	< 1.1:1
RG-91/U *	- - - - - -	TD-13	12.4-18.0 KMC	MEAN < 1.1:1; MAX. 1.2:1
RG-53/U *	- - - - - -	TD-13	18.0-26.5 KMC	MEAN < 1.1:1; MAX. 1.2:1

* MANUFACTURED WITH ARGON TUBES ONLY.

† AVAILABLE WITH EITHER ARGON OR FLUORESCENT TUBE.

2. ARGON TUBE CHARACTERISTICS.

CHARACTERISTIC	TD-10	TD-11	TD-12	TD-13	RBX 103167
ANODE CURRENT, MA DC	250	200	250	200	250
FILAMENT CURRENT, MA DC	170	170	300	170	300
TUBE DISSIPATION	20 W	17 W	22 W	13 W	16 W
TUBE VOLTAGE DROP	80 V	85 V	90 V	65 V	65 V
AMBIENT TEMPERATURE RANGE	-40 TO +165 DEG. F.				

3. MECHANICAL SPECIFICATIONS.

UNIT	OVERALL DIM. (IN)	WEIGHT (LBS)	FLANGE
RG-48/U	24 X 8 X 5	$11\frac{1}{2}$	UG-214/U
RG-49/U	18 X 7 X 4	5	UG-149/U
RG-50/U	17 X 6 X 3	$3\frac{1}{2}$	UG-344/U
RG-51/U	16 X 6 X 3	$2\frac{1}{2}$	UG-51/U
RG-52/U	16 X 5 X 2	2	UG-39/U
RG-53/U	14 X $4\frac{1}{2}$ X $4\frac{1}{2}$	$\frac{1}{2}$	UG-425/U
RG-69/U	12 X 8 X 5	10	UG-417/U
RG-91/U	14 X $4\frac{1}{2}$ X $4\frac{1}{2}$	1	UG-419/U
Power Supply	10 X 7 X $6\frac{1}{2}$	8	- - - -

4. NOISE OUTPUT - ABOVE THERMAL NOISE
   A. FLUORESCENT: 15.84 ± 0.25 DB AT 32°C
   B ARGON GAS: 15 28 ± 0.1 DB

5. POWER REQUIREMENTS.
   A. FLUORESCENT: 40-WATT, 115-V (±10%), 60-CPS, A-C POWER INPUT.
   B. ARGON GAS: 50-WATT, 115-V (±10%), 60-CPS, A-C POWER INPUT

D. EQUIPMENT SUPPLIED.

1. WAVEGUIDE ASSEMBLY, INCLUDING NOISE SOURCE AND HARDWOOD STAND.
2. POWER SUPPLY UNIT.
   A. UNIVERSAL SUPPLY
   B. FLUORESCENT MODELS.
      1. **RG-49/U, RG-50/U, RG-51/U, RG-52/U**.....#320-B
      2. **RG-69/U, RG-48/U**.....#330-B
   C. ARGON MODELS:
      1. **RG-49/U, RG-50/U, RG-51/U, RG-52/U, RG-53/U, RG-91/U**.....#321-A
      2. **RG-69/U, RG-48/U**.....#321-B
3. INTERCONNECTING CABLES.

E. ADDITIONAL EQUIPMENT REQUIRED.

1. POWER INDICATOR.
2. PRECISION IF ATTENUATOR OR RF ATTENUATOR, FOR INSERTED ATTENUATION METHODS.

SECTION II
INSTALLATION

A. GENERAL.

THE **MICROWAVE MEGA-NODES** ARE DESIGNED FOR TABLE-TOP OPERATION AND THUS PRESENT NO SPECIAL INSTALLATION PROBLEMS. HOWEVER, FOR OPTIMUM OPERATION, THE EQUIPMENT SHOULD NOT BE SUBJECTED TO EXCESSIVE MOISTURE, TEMPERATURE OR VIBRATION CONDITIONS. THE INSTALLATION SHOULD INCLUDE PROVISIONS FOR CONNECTION TO 1) A 50-WATT SOURCE OF 115-VOLT (±10%) A-C POWER AND 2) TO THE EQUIPMENT UNDER TEST.

B. ASSEMBLY FOR USE.

1. AFTER UNPACKING THE EQUIPMENT, INSPECT BOTH THE POWER SUPPLY UNIT AND THE WAVEGUIDE ASSEMBLY FOR OBVIOUS SIGNS OF DAMAGE.

2. REMOVE A-C POWER CORD AND TUBE CORDS FROM THE REAR OF THE POWER SUPPLY CABINET. CONNECT A-C PLUG *(P-1)* TO 115-VOLT POWER SOURCE.

WARNING

Ordinary fluorescent lamps contain some beryllium powder. Since beryllium in many forms is poisonous, extreme care should be exercised in handling these lamps to ovoid breakage.

3. REMOVE TAPE FROM FLUORESCENT OR ARGON TUBE. SECURE LAMP CONNECTORS *(P-2* AND *P-3)* TO EACH END OF THE TUBE.

4. USE FLANGE SUPPLIED WITH THE EQUIPMENT TO CONNECT THE WAVEGUIDE TO THE CIRCUIT UNDER TEST.

SECTION III
OPERATION

A. IDENTIFICATION OF CONTROLS.

1. ON-OFF SWITCH *(S-1)*. THIS DPDT SWITCH CONTROLS THE APPLICATION OF ALL A-C POWER TO THE **MICROWAVE MEGA-NODE**. WHEN THIS SWITCH IS IN THE ON POSITION, THE ADJACENT RED LIGHT COMES ON.

2. START SWITCH *(S-2)*. THIS MOMENTARY TOGGLE SWITCH IS DEPRESSED ONLY TO START THE **MICROWAVE MEGA-NODE.**

3. CURRENT INCREASE CONTROL *(R-4)*. THIS POTENTIOMETER PERMITS THE OPERATOR TO ADJUST THE LAMP CURRENT, AS INDICATED ON THE METER, TO PREVENT EXCESSIVE TUBE DISSIPATION.

4. FUSE *(F-1)*. THIS FRONT-PANEL FUSE, SET IN ONE SIDE OF THE A-C LINE IS USED TO PROTECT THE ENTIRE POWER SUPPLY AND NOISE SOURCE ASSEMBLY. IN ARGON TUBE AND UNIVERSAL POWER SUPPLIES IT HAS A TWO-AMPERE RATING; IN EQUIPMENT WHERE A FLUORESCENT TUBE IS USED, ONE-AMPERE.

5. METER. THIS D-C MILLIAMETER, CALIBRATED FROM ZERO TO 250 MA, IS USED IN ADJUSTING THE TUBE CURRENT TO THE PROPER LEVEL.

6. POWER CONNECTIONS. EACH POWER SUPPLY IS EQUIPPED WITH AN A-C POWER CORD, AN OUTPUT CABLE AND TWO INTERCONNECTING CABLES WHICH MATE BOTH WITH THE OUTPUT CABLE AND THE LAMP TERMINALS.

NOTE

The two following controls are used only in the fluorescent tube power supply. They do not appear in the argon model or universal power supplies.

7. POLARITY SWITCH *(S-3)*. THIS DPDT SWITCH IS USED TO REVERSE THE POLARITY OF THE POTENTIAL APPLIED TO THE LAMP. THE LAMP WILL OPERATE SATISFACTORILY IN EITHER POSITION. HOWEVER, IF THE SWITCH IS LEFT IN ONE POSITION FOR LONG PERIODS OF TIME, A PREPONDERANCE OF THE CATHODE MATERIAL WILL ACCUMULATE AT ONE END OF THE TUBE. THIS CONDITION CHARACTERIZED BY A DARK DISCOLORATION, DOES NOT AFFECT THE NOISE OUTPUT BUT MAY SHORTEN THE LIFE OF THE TUBE IF IT IS NOT REMEDIED. IT IS ADVISABLE TO REVERSE THE SWITCH POSITION EVERY TEN OR FIFTEEN MINUTES DURING PROLONGED OPERATION. WHEN THE **MICROWAVE MEGA-NODE** IS USED ONLY FOR SHORT PERIODS OF TIME, THE POSITION OF THE POLARITY SWITCH SHOULD BE CHANGED EACH TIME THE POWER SUPPLY IS ENERGIZED. *Failure to observe this precaution will not affect the accuracy of any measurement made with the* **MICROWAVE MEGA-NODE.**

8. THERMOMETER. THIS ACCURATELY CALIBRATED CENTIGRADE THERMOMETER, PERMANENTLY ATTACHED TO THE WAVEGUIDE ASSEMBLY, IS USED TO OBTAIN AN ACCURATE AND INSTANTANEOUS INDICATION OF TEMPERATURE VARIATION. THE FLUORESCENT TUBE NOISE SOURCES HAVE A CORRECTION FACTOR OF 0.05 DB/DEGREES C ABOUT 32°C.

9. FILAMENT CURRENT CONTROL *(R-7)*. THIS INTERNAL POTENTIOMETER, WHICH IS USED ONLY IN THE ARGON AND UNIVERSAL POWER SUPPLIES, IS USED TO SET THE ARGON TUBE FILAMENT CURRENT TO THE LEVEL SPECIFIED IN SECTION I, PARAGRAPH C-5 BEFORE ENERGIZING THE NOISE SOURCE. THE ACTUAL FILAMENT CURRENT VALUE IS OBTAINED FROM OHM'S LAW BY MEASURING THE VOLTAGE DROP ACROSS *R-6* WHILE DEPRESSING THE START SWITCH.

B. OPERATING INSTRUCTIONS.

1. FLUORESCENT MODELS.

a. ASSEMBLE EQUIPMENT AS DESCRIBED IN SECTION II.

b. TURN POWER SWITCH TO ON POSITION. THE ADJACENT INDICATOR LAMP SHOULD LIGHT UP IMMEDIATELY.

c. REVERSE POSITION OF POLARITY SWITCH.

d. TURN INCREASE CURRENT CONTROL COMPLETELY CLOCKWISE.

e. DEPRESS THE START SWITCH AND ADJUST THE INCREASE CURRENT CONTROL UNTIL THE METER READS FULL SCALE.

f. AFTER 10 TO 15 SECONDS. RELEASE THE START SWITCH THE FLUORESCENT LAMP SHOULD LIGHT, CAUSING THE METER READING TO REMAIN AT FULL SCALE. IF THE LAMP DOES NOT LIGHT, DEPRESS THE START SWITCH FOR ANOTHER 10 TO 15 SECONDS.

g. AFTER THE LAMP LIGHTS, ADJUST THE INCREASE CURRENT CONTROL UNTIL THE METER INDICATES THE CORRECT VALUE FOR THE FREQUENCY IN USE. (SEE *figures 4* THROUGH *8.*)

h. THE NOISE SOURCE IS NOW PRODUCING RANDOM NOISE ACROSS THE ENTIRE USEFUL FREQUENCY RANGE OF THE WAVEGUIDE.

i. IF POSSIBLE, ALLOW A FIFTEEN-MINUTE WARM-UP PERIOD BEFORE USING THE NOISE SOURCE.

j. THE FLUORESCENT MODELS HAVE A TEMPERATURE CORRECTION FACTOR OF 0.05 DB PER DEGREE CENTIGRADE THUS THE OUTPUT POWER IN DECIBELS, P_{OUT}, IS:

$$P_{OUT} = \text{~~15.84 + 0.05 (T-32)~~} \quad 15.84 - 0.05(T-32)$$

Incorrect

WHERE T = THE READING ON THE THERMOMETER IN DEGREES CENTIGRADE. THE THERMOMETER READING SHOULD BE CHECKED *each time* A MEASUREMENT IS MADE.

k IF THE **MICROWAVE MEGA-NODE** IS TO BE USED FOR NOISE FIGURE MEASUREMENTS, FOLLOW THE PROCEDURE OUTLINED IN PARAGRAPHS B-3 OR B-4 BELOW

2. ARGON MODELS.

a. ASSEMBLE THE EQUIPMENT AS DESCRIBED IN SECTION II

b. TURN POWER SWITCH TO ON POSITION. THE ADJACENT INDICATOR LAMP SHOULD LIGHT UP IMMEDIATELY.

c. CONNECT THE VOLTMETER ACROSS RESISTOR *R-6*. WITH START SWITCH DEPRESSED, ADJUST POTENTIOMETER *R-7* UNTIL VOLTAGE DROP ACROSS *R-6* CORRESPONDS TO THE APPROPRIATE VALUE IN THE TABULATION BELOW.

RG-48/U, RG-69/U	300 VOLTS.
RG-52/U, RG 53/U, RG-91/U, RG-49/U, RG-50/U, RG-51/U	170 VOLTS.

d. AFTER TEN TO FIFTEEN SECONDS, RELEASE THE START SWITCH. THE ARGON LAMP SHOULD LIGHT.

e. ADJUST INCREASE CURRENT CONTROL UNTIL METER READING CORRESPONDS TO THAT SHOWN IN SECTION I, PARAGRAPH C-5.

f. IF THE **MICROWAVE MEGA-NODE** IS TO BE USED FOR NOISE FIGURE MEASUREMENTS, FOLLOW THE PROCEDURE OUTLINED IN PARAGRAPHS B-3 OR B-4 BELOW.

3. MEASUREMENT OF NOISE FIGURE BY DIRECT COMPARISON (SEE *figure 2*). IN THIS METHOD THE CALIBRATION OF THE POWER INDICATOR MUST BE KNOWN AND ACCURATE

a. CONNECT ONE END OF THE NOISE SOURCE WAVEGUIDE TO THE RECEIVER UNDER TEST. IF THE NOISE SOURCE WAVEGUIDE IS FLANGED AT BOTH ENDS, EITHER END MAY BE CONNECTED TO RECEIVER. WHEN THE TUBE IS OPERATING, BOTH ENDS OF THE WAVEGUIDE ARE PROPERLY TERMINATED. CONSEQUENTLY, THE TYPE OF TERMINATION ON THE UNATTACHED END IS UNIMPORTANT.

b. Energize the **MICROWAVE MEGA-NODE** as described above. Record the noise power of the circuit under test.

c. Remove the **MICROWAVE MEGA-NODE.** Connect the receiver input to a matched load. Record the reading on the power indicator.

d. The noise figure, F, may be computed from the formula:

$$F = \frac{38.29}{Y - 1}$$

where Y is the ratio of noise power obtained in step *b* (with the **MICROWAVE MEGA-NODE** in circuit) to that obtained in step *c* (matched load in circuit).

EXAMPLE:

If the noise power output with the matched load on equals 0.05 watts and the noise power output with the **MICROWAVE MEGA-NODE** on equals 0.25 watts, then

$$Y = \frac{0.25}{0.05} = 5, \text{ and}$$

$$F = \frac{38.29}{5-1} = 9.57$$

CAUTION

Since noise contains components whose amplitude for brief periods may be much greater than r.m.s. noise power, great care should be taken to make certain that no overload occurs in the receiver, even at CW levels four times those of the noise levels encountered. It is also important to determine the law of the power indicator. Both the input-out characteristic of the receiver and the power indicator characteristic may be determined by measurements with a calibrated signal generator.

4. Measurement of Noise Figure by Inserted Attenuation Techniques (see *figures 2b* and *2c*). By utilizing either a precision I-F attenuator, R-F attenuator or both, this method eliminates the necessity for calibrating the receiver input-output characteristic. If the noise figure of the receiver under test is very low, full output power of the **MICROWAVE MEGA-NODE** may tend to overload any receiver whose output capabilities are limited.

Most receivers, however, can handle an output power twice that due to noise alone. If, then, an R-F attenuator is placed between the **MICROWAVE MEGA-NODE** and the input of the receiver, the attenuation may be adjusted to produce an output power twice that available with the receiver input terminated in the normal (Z_0) input impedance. Thus Y, the ratio of output noise power with a **MEGA-NODE** connected to output noise power with the load connected, equals 2, and F, the noise figure, then may be calculated from the formula,

$$F = (15.84 - \alpha) \text{ DB}^*$$

If it is possible to insert a precise amount of attenuation in the IF amplifier (e.g., when the amplifier is composed of a preamplifier and main amplifier), this system of measurement becomes even simpler. The noise output of the receiver with Z_0 input termination is adjusted to a convenient value. Then, with the **MICROWAVE MEGA-NODE** connected to the input through the RF attenuator, a 3-db IF attenuation is inserted.

The RF attenuator is adjusted to return the power indicator to the *same* reading as before. The noise figure may then be calculated by the equation above. Since, the power indicator is always operating at the same level and on the same kind of signal (noise) under both conditions of the measurement, overload effects are less important and very simple power indicators may be used. This is true, however, only if the 3-db IF attenuation is introduced at a low level before overload occurs. Under these circumstances, simple measurement of IF detector rectified d-c voltage is a satisfactory indication of relative power output.

Another advantage of the above scheme is that normal RF attenuators may be adjusted to produce a high insertion loss. Consequently, with the lamp off and the attenuator at maximum (20 db or more), the receiver effectively will "see" an input termination sufficiently close to Z_0 to eliminate the necessity of replacing the **MICROWAVE MEGA-NODE** with a Z_0 load.

If only the IF attenuator is available, the above method may be employed with slight variation, retaining the "constant output" technique. Sufficient IF attenuation is inserted to bring the power output reading back to the original reading (with Z_0 at room temperature at the input). When a fluorescent noise source

* *For argon lamps,* $F = (15.28 - \alpha)$ DB.

IS USED, THE NOISE FIGURE THEN MAY BE CALCULATED FROM THE FOLLOWING:

$$F = 15.84 - 10 \log_{10} (A-1) \text{ DB.}$$

WHERE A IS THE INSERTED IF ATTENUATION, EXPRESSED AS A POWER RATIO. FOR EXAMPLE, IF THE IF ATTENUATION REQUIRED IS 6 DB, THAT IS, A POWER RATIO OF 4:1,

$$F = 15.84 - 10 \log_{10} (4-1)$$

$$= 15.84 - 4.77 = 11.07 \text{ DB.}$$

OR, IF ONLY 1.5 DB (1.41:1 POWER RATIO) IS REQUIRED,

$$F = 15.84 - 10 \log_{10} (1.41-1)$$

$$= 15.84 + 3.87 = 19.71 \text{ DB.}$$

BY SUBSTITUTING A 15.28 VALUE FOR THE NOISE SOURCE OUTPUT, THE SAME FORMULA MAY BE APPLIED TO ARGON SOURCES. NOTE THAT IF THE TEMPERATURE OF A FLUORESCENT WAVEGUIDE IS NOT 32°C, THE TEMPERATURE CORRECTION FACTOR OF +0.05 DB/°C ABOVE 32°C MUST BE ADDED TO ALL MEASUREMENTS.

SINCE THE **MICROWAVE MEGA-NODES** HAVE BEEN DESIGNED TO PRESENT A MATCHED LOAD TO THE LINE CONNECTING THEM TO THE TERMINALS OF THE RECEIVER UNDER TEST, NO MATCHING SECTIONS ARE REQUIRED. IF A MATCHING DEVICE IS NEEDED TO INCREASE THE EFFICIENCY OF POWER TRANSFER BETWEEN THE **MEGA-NODE** AND RECEIVER, IT INDICATES A MISMATCH AT THE RECEIVER TERMINALS. THE ABOVE DEFINITION OF NOISE FIGURE SPECIFICALLY RULES OUT MATCHING DEVICES — IT USES THE *available power* FROM THE SOURCE AND NOT THE POWER TRANSFERRED FROM SOURCE TO RECEIVER. IF THE RECEIVER IS TO OPERATE FROM Z_0 SOURCE IN THE FIELD, ANY LOSS OF POWER IN THE TRANSFER SHOULD BE REFLECTED IN A POORER NOISE FIGURE FOR THE RECEIVER.

IT IS TACITLY ASSUMED THAT THE RECEIVER HAS ONLY A SINGLE RESPONSE — WITHOUT SPURIOUS RESPONSES SUCH AS IMAGES OR HARMONICS. IF SPURIOUS RESPONSES IN THE FREQUENCY RANGE OF THE **MEGA-NODE** ARE PRESENT, THE RECEIVER WILL ACCEPT NOISE FROM THE **MICROWAVE MEGA-NODE** AT THE SPURIOUS FREQUENCIES AS WELL AS ON THE DESIRED CHANNEL. THE ACCEPTED DEFINITION OF NOISE EMPLOYS THE CONCEPT OF THE "USEFUL CHANNEL BANDWIDTH"[1,2]. IF A NOISE GENERATOR IS USED IN THE NOISE FIGURE MEASUREMENT, A CORRECTION MUST BE MADE TO ACCOUNT FOR SPURIOUS RECEIVER RESPONSES. IF F IS THE NOISE FIGURE AS MEASURED BY THE ABOVE METHOD AND F_T IS THE TRUE NOISE FIGURE, BOTH EXPRESSED AS POWER RATIOS, THEN

$$F_T = F \frac{B}{B_U} .$$

WHERE B IS THE TOTAL BANDWIDTH, INCLUDING SPURIOUS RESPONSES, AND B_U IS THE USEFUL CHANNEL BANDWIDTH IN CPS. FOR EXAMPLE, WHEN MEASURING A RECEIVER WHICH HAS A COMPLETE IMAGE (IMAGE RESPONSE EQUAL TO THE DESIRED RESPONSE), THE RATIO B/B_U IS 2, AND 3 DB MUST BE ADDED TO THE MEASURED NOISE FIGURE TO OBTAIN THE TRUE NOISE FIGURE.

SECTION IV
THEORY OF OPERATION

A. GENERAL THEORY OF NOISE SOURCES.

AS INDICATED ABOVE, THE NOISE SOURCES USED IN THE **MICROWAVE MEGA-NODES** ARE EITHER COMMERCIAL FLUORESCENT LAMPS OR ARGON LAMPS. IN STUDYING THE UTILITY OF GAS-FILLED LAMPS AS A NOISE SOURCE, W.W.MUMFORD[3] HAS FOUND THAT:

"IN A GASEOUS DISCHARGE WHICH IS RADIATING LIGHT ENERGY SUBSTANTIALLY MONOCHROMATICALLY AT A PARTICULAR WAVELENGTH λ_M, THE NOISE OUTPUT AT MICROWAVE FREQUENCIES IS THE SAME AS THAT AVAILABLE FROM A BLACK BODY WHICH RADIATES ITS MAXIMUM ENERGY AT THAT WAVELENGTH"

THE WAVELENGTH OF MAXIMUM RADIATION FOR A BLACK BODY MAY BE DETERMINED FROM WIEN'S DISPLACEMENT LAW:

$$\lambda_M T = .289 \text{ DEG.CM.}$$

WHERE T = TEMPERATURE OF THE RADIATING BODY IN DEGREES KELVIN AND

λ_M = WAVELENGTH IN CM.

IT HAS BEEN SHOWN THAT RADIATION FROM THE MERCURY VAPOR DISCHARGE IN A STANDARD FLUORESCENT LAMP IS CONCENTRATED IN A SINGLE SPECTRAL LINE

1. *Friis, H.T., Proceedings IRE, 32: 419-422, July 1944.*
2. *North, D.O., Proceedings IRE, pp.125-127, 1945.*
3. *Mumford, W.W., A Broad-Band Microwave Noise Source; BELL SYSTEMS TECHNICAL JOURNAL 28: 606 – 619, Oct. 1949.*

(λ_M = 2536.52 (10)$^{-8}$CM). NO MORE THAN ABOUT 2% OF THE TOTAL ENERGY IS RADIATED AT OTHER WAVELENGTHS. USING THIS WAVELENGTH IN THE WIEN LAW ABOVE YIELDS AN EQUIVALENT LAMP OPERATING TEMPERATURE (T_2) OF 11,400° K. IF MUMFORD'S HYPOTHESIS IS ASSUMED TO BE TRUE, THIS TEMPERATURE REPRESENTS A NOISE POWER OF 15.84 DB ABOVE THE IDEAL AVAILABLE INPUT NOISE POWER, kTB. (SEE DISCUSSION IN PARAGRAPH B BELOW.) MEASUREMENTS BY MUMFORD CHECK THIS RESULT CLOSELY.

MUMFORD HAS FOUND THAT THE NOISE OUTPUT OF A FLUORESCENT LAMP IS SUBSTANTIALLY INDEPENDENT OF THE FLUORESCENT COATING AND OF CURRENT DENSITY, BUT IS SLIGHTLY AFFECTED BY TEMPERATURE. SINCE THESE MEASUREMENTS OF ABSOLUTE NOISE OUTPUT POWER WERE MADE WITH A GUIDE TEMPERATURE OF 17°C, A TEMPERATURE CORRECTION FACTOR MUST BE ADDED TO THE CALCULATED NOISE OUTPUT OF ALL FLUORESCENT MODELS FOR WAVEGUIDE TEMPERATURES OF DIFFERENT VALUE. SEVERAL SEPARATE STUDIES HAVE ARRIVED AT A CLOSELY SIMILAR TEMPERATURE CORRECTION FACTOR OF 0.05 DB PER DEGREE CENTIGRADE. EACH FLUORESCENT NOISE GENERATOR UNIT OF THE **MICROWAVE MEGA-NODES** IS EQUIPPED WITH A PERMANENTLY INSTALLED THERMOMETER FOR RAPID DETERMINATION OF THE TEMPERATURE CORRECTION FACTOR.

B. THEORY OF NOISE FIGURE MEASUREMENTS.

THE THERMAL NOISE ENERGY OF AN IDEAL CONDUCTOR (ONE THAT GENERATES NO NOISE OF ITS OWN OTHER THAN THAT DUE TO THERMAL ACTIVITY OF THE INDIVIDUAL ELECTRONS) MAY BE STATED AS A FUNCTION OF THE ABSOLUTE TEMPERATURE (T) IN DEGREES KELVIN AND THE BANDWIDTH (B) OF THE GENERATED NOISE IN CPS. THE AVAILABLE NOISE POWER FROM AN IDEAL SIGNAL GENERATOR MAY BE FORMULATED AS:

$N = kTB$

WHERE k = BOLTZMAN'S CONSTANT = 1.38 x 10^{-23}

HOWEVER, IN ANY CIRCUIT INCORPORATING A VACUUM TUBE (AS CONTRASTED TO AN IDEAL CONDUCTOR), AN ADDITIONAL AMOUNT OF NOISE WILL BE GENERATED AS A CONSEQUENCE OF THE GREATER RANDOMNESS OF ELECTRON TRAVEL IN THE TUBE. THEN THE NOISE FIGURE OF SUCH A CIRCUIT - A MEASURE OF THE ADDITIONAL NOISE GENERATED IN AN ACTUAL RATHER THAN AN IDEAL CIRCUIT - MAY BE DEFINED AS:

$$F = \frac{\text{AVAILABLE SIGNAL-TO-NOISE RATIO AT INPUT}}{\text{AVAILABLE SIGNAL-TO-NOISE RATIO AT OUTPUT}}$$

THIS BASIC EQUATION CAN BE MODIFIED IN A NUMBER OF WAYS, DEPENDING ON THE METHOD USED FOR MAKING THE PARTICULAR MEASUREMENT. FOR EXAMPLE, IF A SIGNAL GENERATOR IS USED AS A POWER SOURCE, THE EQUATION MAY BE MODIFIED TO:

$F = S_G/MKTB$

WHERE S_G IS THE MAXIMUM AVAILABLE SIGNAL POWER FROM THE SOURCE IN WATTS,

M IS THE RATIO OF SIGNAL POWER TO NOISE POWER AT THE OUTPUT OF THE CIRCUIT UNDER TEST,

K IS BOLTZMAN'S CONSTANT, 1.38 x 10^{-23}

T IS THE ABSOLUTE TEMPERATURE OF THE NOISE SOURCE IN DEGREES KELVIN,

B IS THE BANDWIDTH, OVER WHICH THE NOISE IS OBSERVED, IN CPS.

IF ON THE OTHER HAND, A HOT-BODY NOISE SOURCE IS USED, THE EQUATION FOR NOISE FIGURE MAY BE WRITTEN AS:

$$F = \frac{[(T_2/290)-1]}{(Y-1)}.$$

WHERE T_2 IS THE EFFECTIVE TEMPERATURE IN DEGREES K. OF THE HOT BODY AND

Y IS THE RATIO OF THE NOISE POWER FROM NETWORK WHEN THE SOURCE IS AT T_2 TO THAT WHEN IT IS AT ROOM TEMPERATURE.

SINCE T_2 FOR THE LAMPS IN USE IS 11,400°K.

$\frac{T_2}{290} - 1 = 38.29$ AND

$$F = \frac{38.29}{Y-1}$$

C. WAVEGUIDE TERMINATIONS.

ALL OF THE WAVEGUIDES OF THE **MICROWAVE MEGA-NODES** ARE TERMINATED AT ONE END IN A JAN COVER FLANGE. IN THE EARLIER MODELS, ONE END OF THE **RG-50/U, RG-51/U, RG-52/U,** AND **RG-69/U** WAVEGUIDES IS TERMINATED IN A SHORT CIRCUIT.

IT HAS BEEN DETERMINED THAT THE **RG-48/U** AND **RG-49/U** DIODES MAY BE INSERTED IN A SECTION OF LINE WITHOUT INTRODUCING SERIOUS DISCONTINUITIES PROVIDED THAT THE LAMP IS IN POSITION AND IS TURNED *off*. THAT IS, IF THESE UNITS ARE CONNECTED BETWEEN A RECEIVER AND A MATCHED LOAD, THEY WILL PRESENT A MATCHED LOAD TO THE RECEIVER BOTH AT ROOM TEMPERATURE (WITH THE LAMP TURNED OFF) AND AT 11,400°K (WITH THE LAMP ON). FOR THIS REASON, FLANGES HAVE BEEN PROVIDED AT BOTH ENDS OF THESE GUIDES ON BOTH THE EARLIER AND LATER MODELS.

IN THE SIX OTHER GUIDES MENTIONED ABOVE, THE DISCONTINUITIES INTRODUCED BY THE DE-ENERGIZED LAMP ARE MORE SERIOUS AND PROHIBIT THE USE OF THIS TECHNIQUE. THE CONDITION OF THE UNUSED END IS UNIMPORTANT.

D. EFFECTS OF OPPOSITE END TERMINATIONS

The available power output of the noise source is substantially independent of the termination at the opposite end of the waveguide. This condition is brought about by the insertion losses introduced in the guide by the ignited lamp. The magnitude of these losses is such that substantially none of the power radiated away from the receiver and reflected from the opposite termination (whether short or open) will appear at the receiver end of the guide. The termination of the unused end is, therefore, unimportant with the lamp ignited, except for the possible leakage problem encountered with poorly shielded receivers. It would be possible to obtain 15.84 db noise from each end of the generator at the same time if desired.

E. VSWR.

A low VSWR (and the insertion loss mentioned above) are obtained by tilting the tube at an acute angle to the guide. Although the lamp at any one point is not matched to the guide impedance, the reflections from the various points of the lamp (there are several wavelengths of the lamp in the guide) cancel each other out to a large extent. The actual impedance match of the lamp to the guide is modified only slightly by the lamp current. Good results may be obtained over the entire recommended operating range of a given waveguide by operating the lamp at the recommended currents.

One of the problems encountered in the use of fluorescent lamps as noise sources has been the presence of audio oscillations across the lamp. No method of eliminating the oscillations by external circuits is known; and, as can be seen from the curve on VSWR, the impedance match of the lamp to the guide is affected slightly by lamp current. If, then, the current varies at an audio rate, the impedance of the generator will vary at the same rate, and the power delivered by the generator to a constant load will be similarly modulated. However, in the **MICROWAVE MEGA-NODES**, where the lamp is mounted at an acute angle to the waveguide, the variation of impedance with tube current is extremely small. Since the actual tube current variations due to these oscillations are also small, the output impedance variation is almost negligible. It has not been possible to see other than random noise in the output of a receiver under test with these generators.

F. POWER SUPPLY.

All later models of the **MICROWAVE MEGA-NODE** are furnished with a 'universal' power supply which may be used with any of the argon or fluorescent noise sources. *Figure 8* is a schematic of this supply. In the earlier models, seperate supplies were provided for the fluorescent and argon sources (see *figures 9* and *10* respectively). All of these supplies are well-filtered variable-current sources containing a starter for the lamp and an output current control. Lamp current is monitored by a panel-mounted milliameter.

SECTION V
MAINTENANCE

A. GENERAL

The simplicity of the **MICROWAVE MEGA-NODES** eliminates the necessity for any elaborate maintenance procedure. The most troubles encountered with the **MICROWAVE MEGA-NODE** are leaky capacitors, defective crystal diodes, or gas tube failures. The lamp current meter and the front-panel light are the two main indicators on the **MICROWAVE MEGA-NODE.**

If the indicator light does not come on when the ON-OFF switch is in the ON position, check the a-c supply, the front-panel fuse (F-1), and the indicator light. If fuse F-1 blows again on replacement, attempt to determine the cause of failure before replacing it a second time. Check particularly the electrolytic capacitor (C-1) and the germanium diodes (D-1 and D-2).

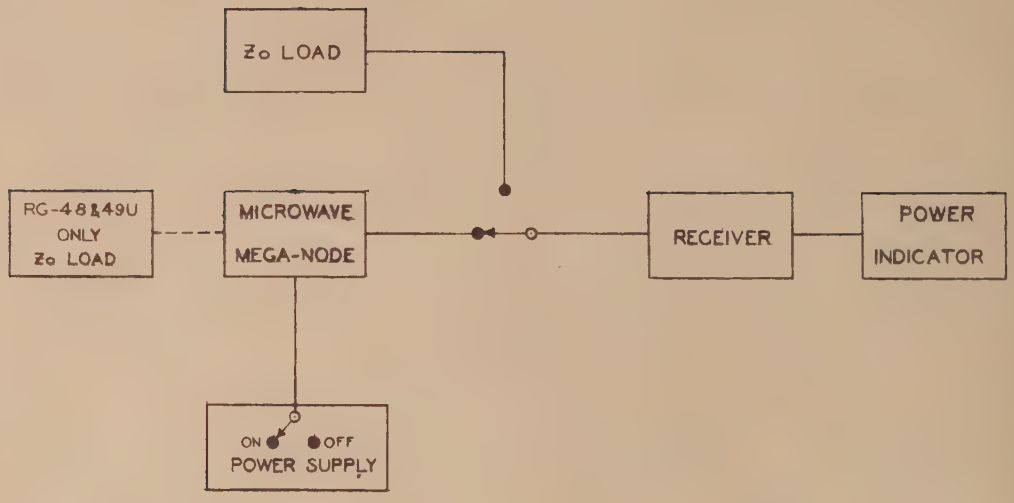
If the meter still reads zero when the START switch is depressed, check the operating procedure. See SECTION III, paragraphs B-2 and B-3. If all potentiometer settings appear to be correct, check the fluorescent or argon lamp itself. To replace the lamp, remove the plugs from each end. The lamp may be removed by pressing against the lower end of the tube.

If the procedure outlined above does not correct the defect, deenergize the equipment and make the resistance checks on the power supply.

SECTION VI
PARTS LIST

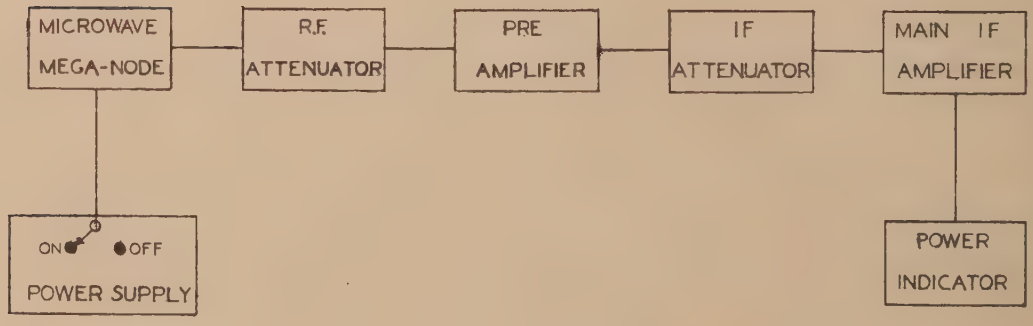
	A - UNIVERSAL	B - FLUORESCENT	C - ARGON
RESISTORS			
R-1	10 Ω. 2 W.	10 Ω. 2 W.	10 Ω. 2 W.
R-2	10 Ω. 2 W.	10 Ω. 2 W.	10 Ω. 2 W.
R-3	10 Ω. 2 W.	200.20 W.	10 Ω. 2 W.
R-4	10 Ω. 2 W.	1 K. 25 W. POT INCREASE I.	350. 50 W. POT INCREASE I.
R-5	560 K.	———	560 K.
R-6	1 K. 50 W.	———	1 K. 50 W
R-7	350. 50 W. POT INCREASE I.	———	750. 25 W. POT
R-8	1 K. 50 W.	———	500. 50 W.
R-9	750. 25 W. POT	———	10. 2 W.
CAPACITORS			
C-1 *a*	40 μf 150 V ELECTROLYTIC	40 μf 150 V ELECTROLYTIC	40 μf 150 V ELECTROLYTIC
C-1 *b*	40 μf 150 V ELECTROLYTIC	40 μf 150 V ELECTROLYTIC	40 μf 150 V ELECTROLYTIC
C-2	40 μf, 450 V	5000 μμf, 600 V PAPER	———
C-3	.02 μf 500 V DISC CERAMIC	———	40 μf 450 V
C-4	.02 μf 500 V DISC CERAMIC	———	.01 μf
C-5	.02 μf 500 V DISC CERAMIC	———	.01 μf DISC CERAMIC
C-6	———	———	.01 μf DISC CERAMIC
SWITCHES			
S-1 ON-OFF	DPST	DPST	DPST
S-2 START	DPST MOMENTARY	SPST MOMENTARY	SPST MOMENTARY
S-3 POLARITY	———	DPDT	———
MISCELLANEOUS			
L-1, COIL	4 *h*	GE 58G690	8.5 *h*, 120 Ω D-C
D-1	← FT & R 1010 SELENIUM RECTIFIER →		
D-2	← FT & R 1010 SELENIUM RECTIFIER →		———
M-1, METER	← 0-300 MA MILLIAMETER →		
F-1, FUSE	2 AMP	2 AMP	1 AMP
I-1	120 V, 3 W, SCREW TYPE	120 V, 6 W, SCREW TYPE	120 V, 6 W, SCREW TYPE
V-1	T-5, T-8, TD-11, TD-12 OR TD-13	T-5 (8 W.) OR T-8 (15 W.)	BENDIX TD-11, TD-12 OR TD-13

4/19/55



A.- BY DIRECT COMPARISON

B.- WITH INSERTED ATTENUATOR



C- WITH TWO INSERTED ATTENUATORS

Fig. 2 Interconnection Block Diagrams, Noise Figure Measurements

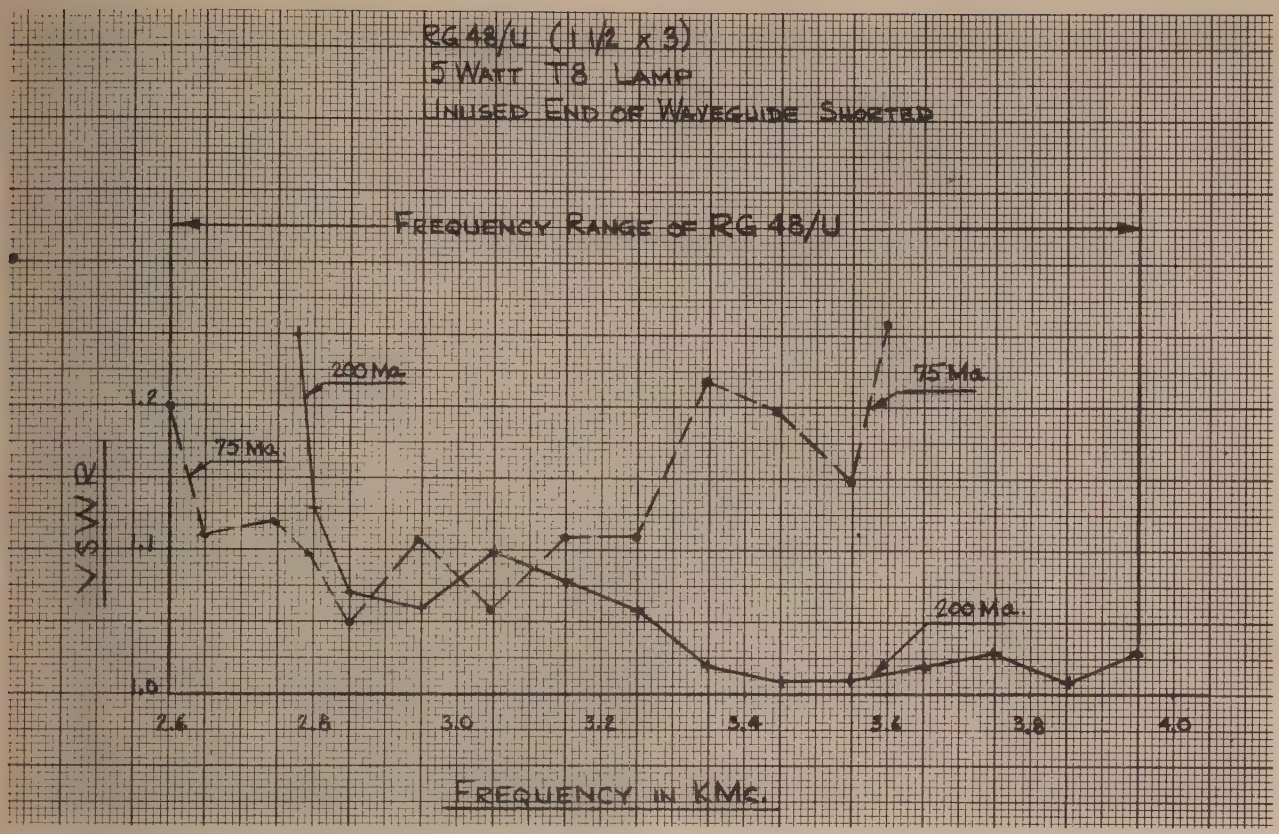


Fig. 3 **RG-48/U,** *VSWR versus Frequency*

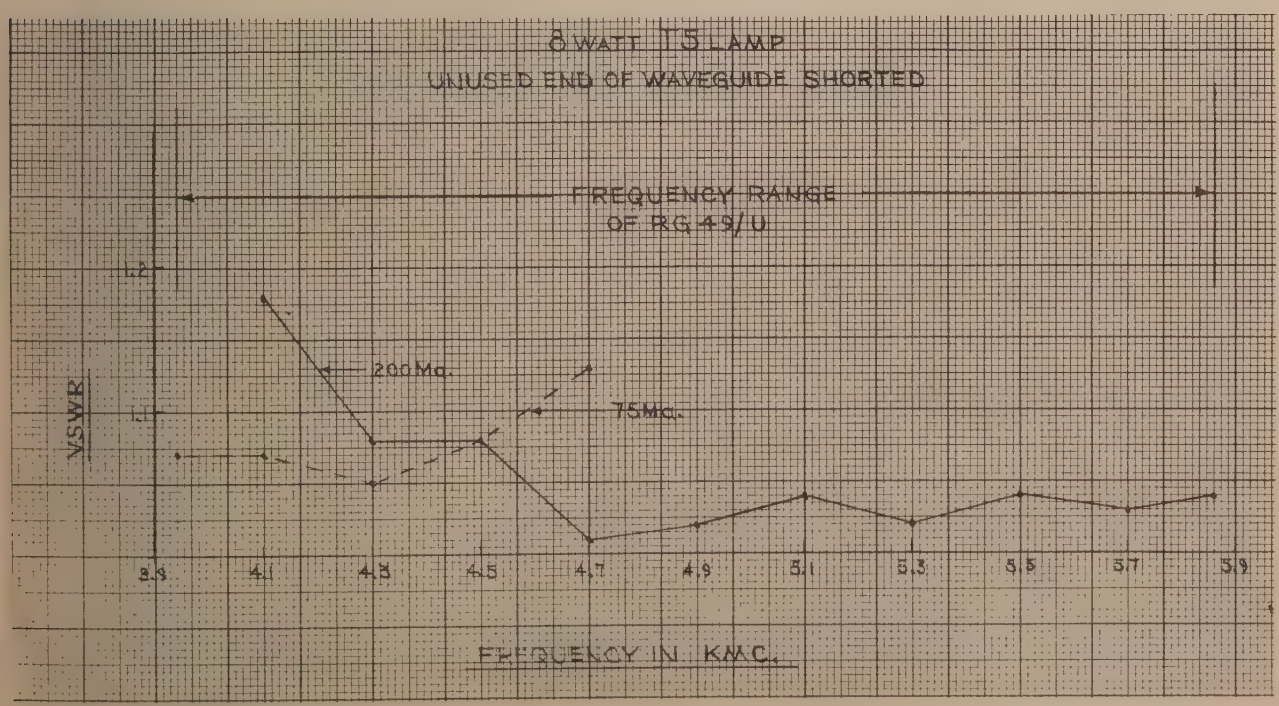


Fig. 4 **RG-49/U,** *VSWR versus Frequency*

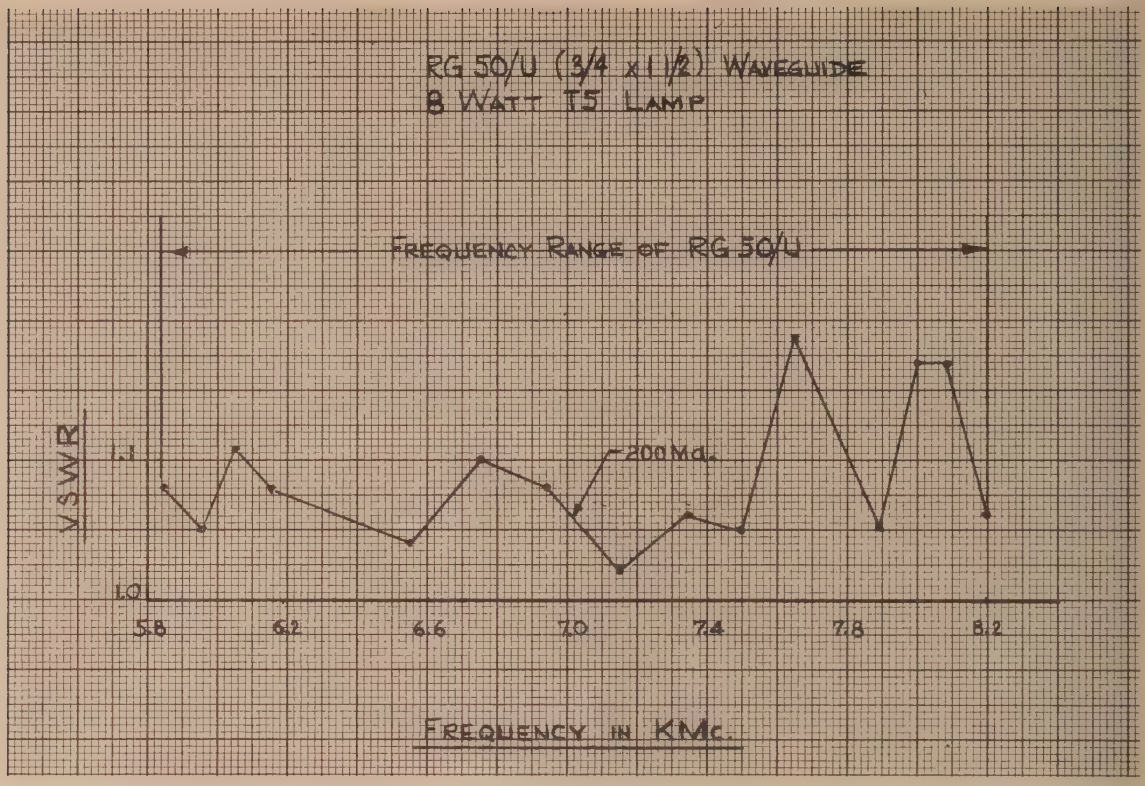


Fig. 5 **RG-50/U,** *VSWR versus Frequency*

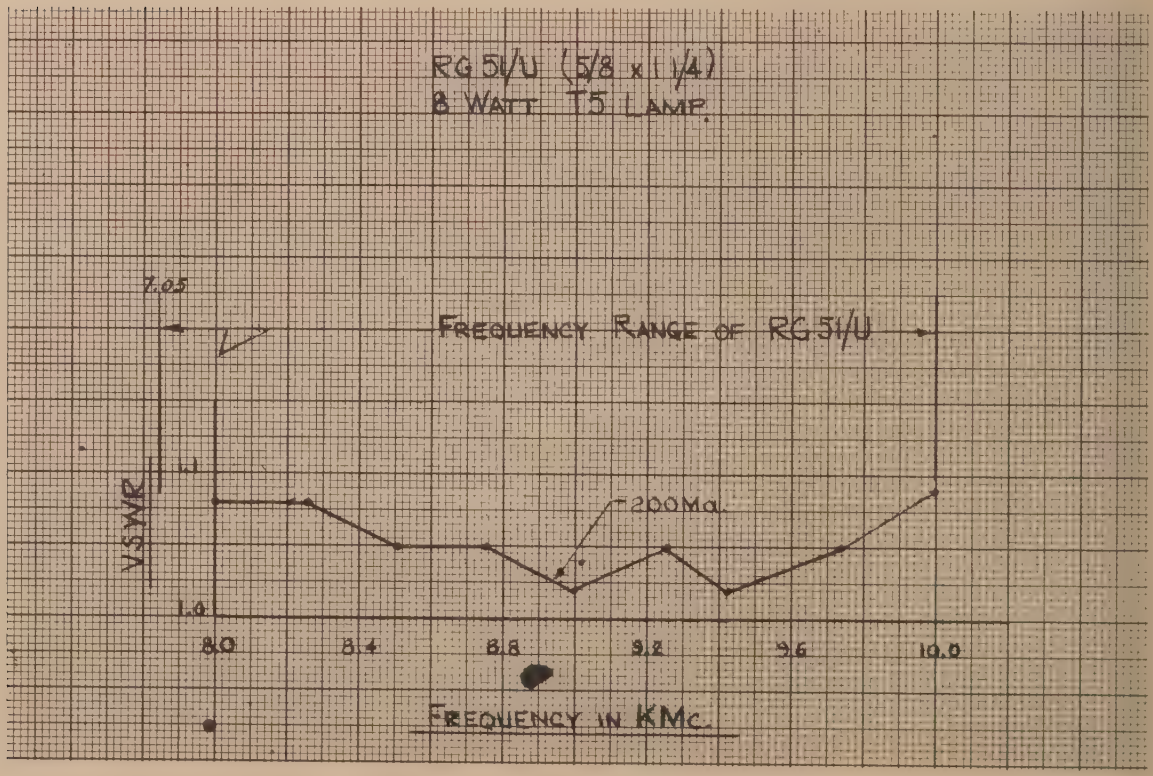


Fig. 6 **RG-51/U,** *VSWR versus Frequency*

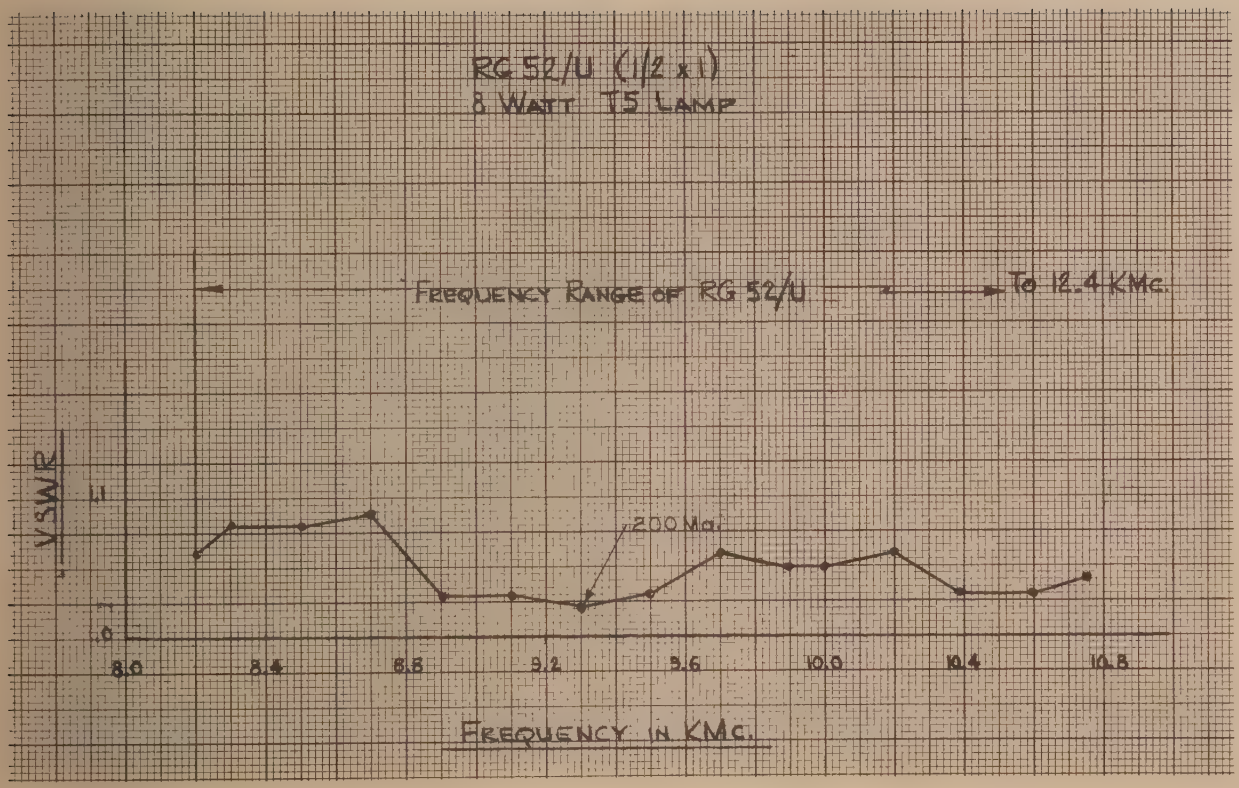
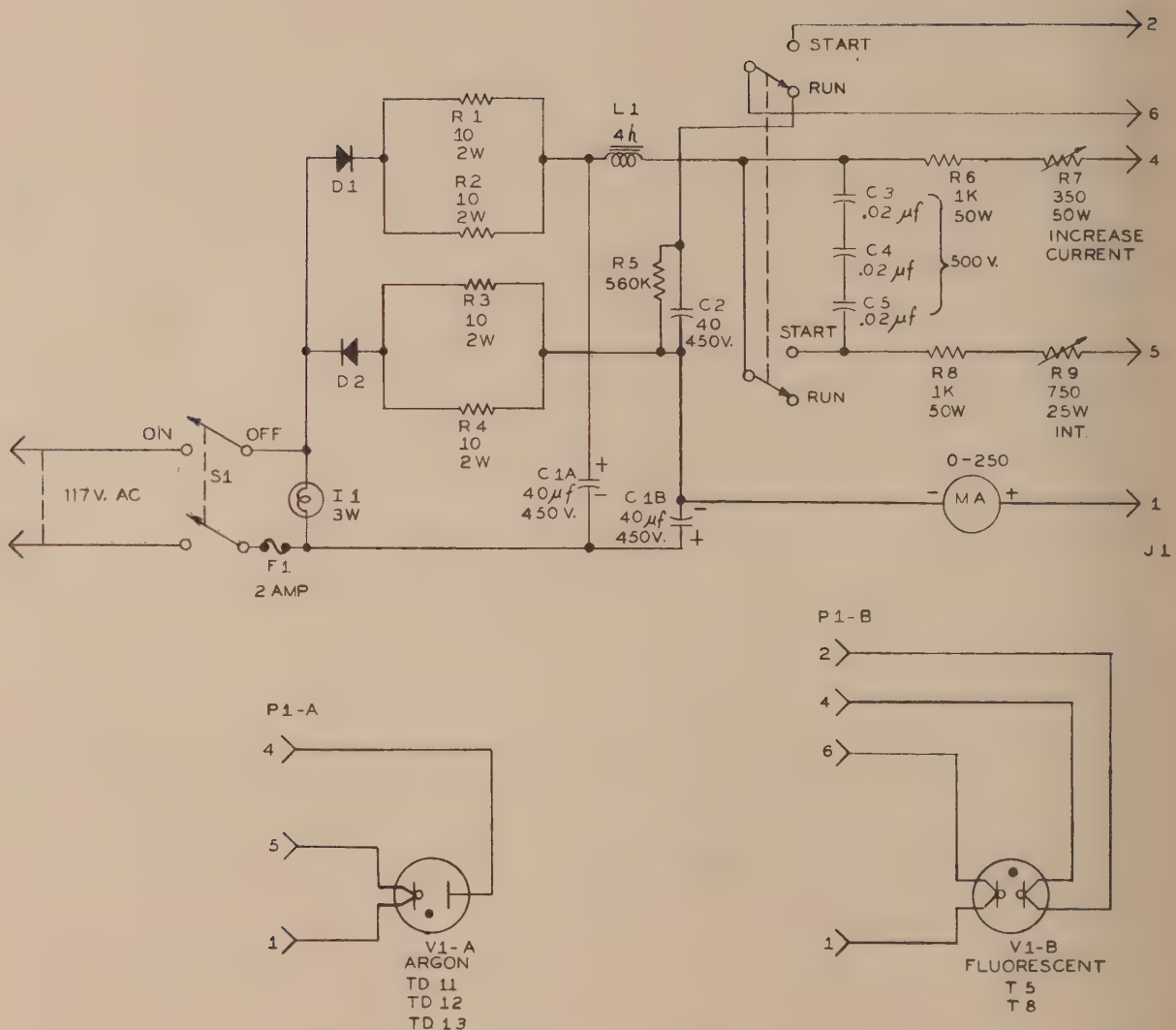


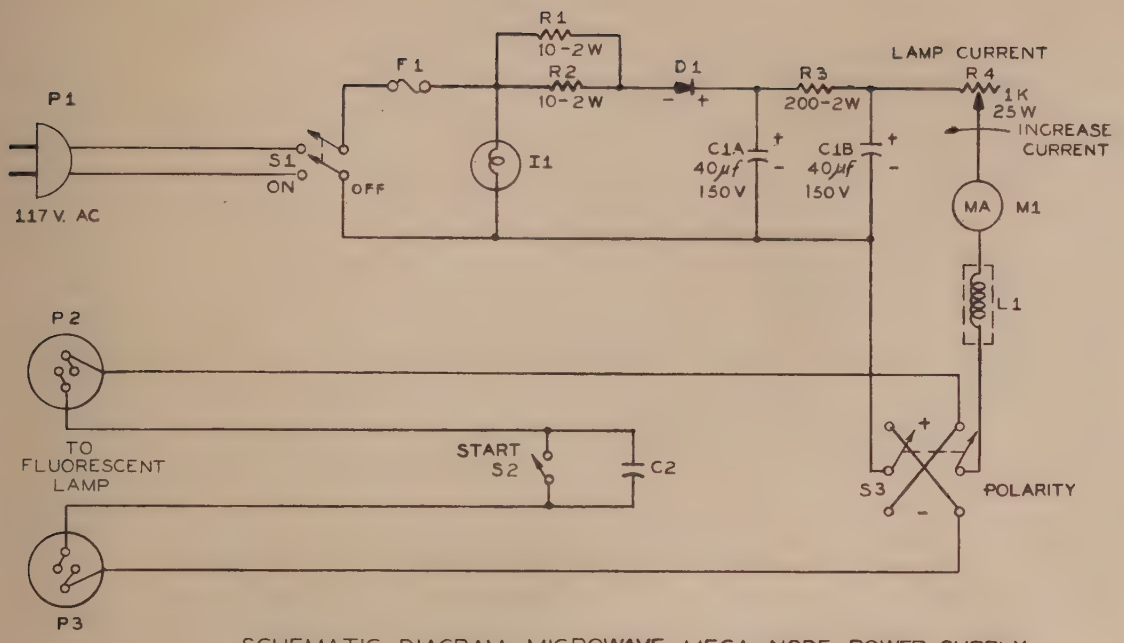
Fig. 7 **RG-52/U,** *VSWR versus Frequency*



SCHEMATIC DIAGRAM MICROWAVE MEGA-NODE POWER SUPPLY
UNIVERSAL MODEL

KAY ELECTRIC CO. PINE BROOK, N. J.

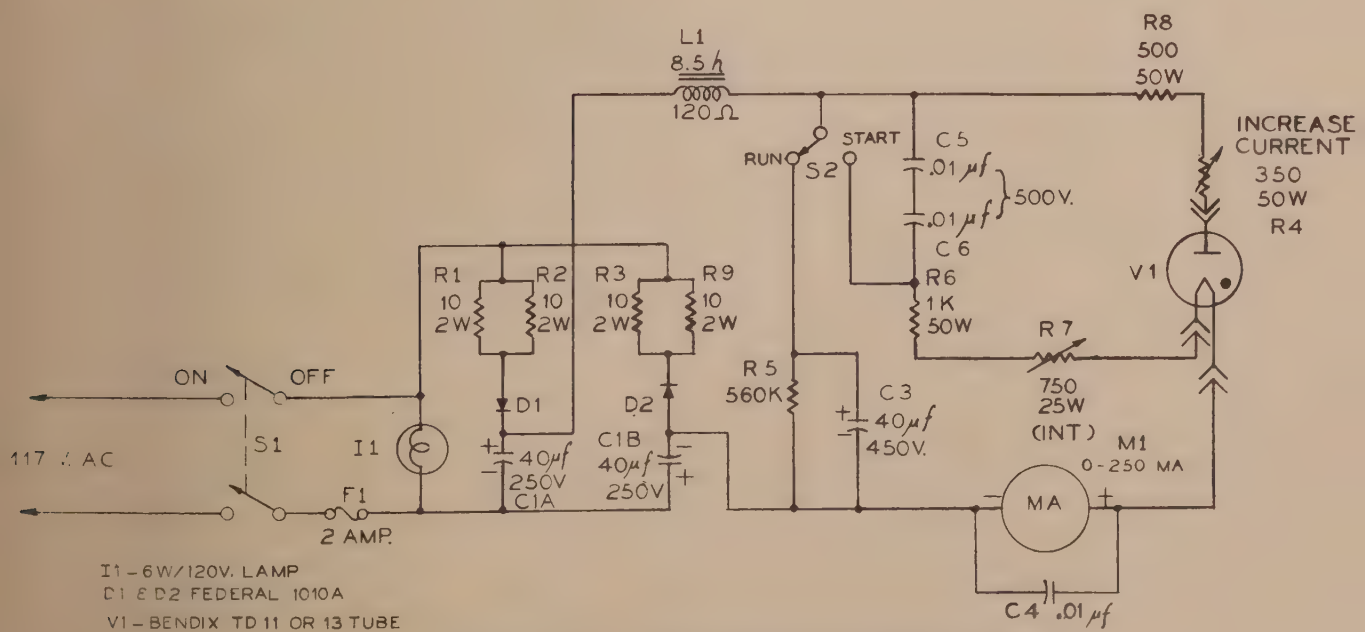
Fig. 8 Complete Schematic, Universal Power Supply



SCHEMATIC DIAGRAM MICROWAVE MEGA-NODE POWER SUPPLY

KAY ELECTRIC CO PINE BROOK, N. J.

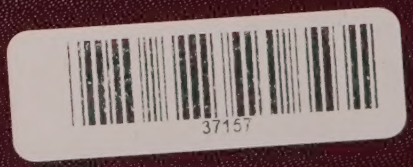
Fig. 9 Complete Schematic, Power Supply for Fluorescent Models



SCHEMATIC MICROWAVE MEGA-NODE POWER SUPPLY
MODEL – 52

KAY ELECTRIC CO. PINE BROOK. N. J.

Fig. 10 Complete Schematic, Power Supply for Argon Models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